GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: Chemical Engineering (05)
SUBJECT NAME: Chemical Reaction Engineering-II
SUBJECT CODE: 2170501
B.E. 7th Semester

Type of course: Chemical Engineering

Prerequisite: A course on Chemical Reaction Engineering-I (2160506)

Rationale: In this subject emphasis is on heterogeneous reaction engineering and non-ideal reactors, catalysis, leading finally to design considerations. The first part of this subject deals with residence time distributions, and how they can be used to characterize and design non-ideal reactors. Kinetics and design of reactors for non-catalytic fluid-fluid and fluid-particle reactions follows. And the last part of the subject deals with catalysis and catalytic reaction kinetics.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	3	6	70	20	10	20	10	20	150

Contents:

Sr. No.	Content	Total Hrs.	% Weightage
1.	**Non-Ideal Flow:** Basics of non-ideal flow, Residence time distribution, stimulus response techniques, The E,F and C Curves, their interrelationship, conversion in non-ideal flow reactors, Dispersion model, Chemical Reaction and dispersion, Intensity of fluid mixing. Tanks in series model, Deviation from plug flow, Models for real stirred tanks.	**10**	**18**
	Heterogeneous Non-Catalytic Systems:		
2.	**Heterogeneous Reactions: Introduction:** Rate steps involved in heterogeneous systems, Overall rate expression for linear and non linear process, contacting patterns for two-phase systems.	**4**	**9**
3.	**Fluid-Fluid systems:** Rate equation, rate equation for straight mass transfer, kinetic regimes of mass transfer and chemical reaction, rate equation for mass transfer and chemical reactions, film conversion parameter, fluid-fluid reactor design.	**8**	**14**
4.	**Fluid-Particle systems:** Fluid partial reaction kinetics, selection of a model, Shrinking Core Model for unchanging and changing size spherical partials, Diffusion through gas film and through ash layer controlling, Chemical reaction controlling, Shrinking core model, its limitations, Determination of rate controlling step.	**8**	**14**

Solid Catalyzed systems:			
5.	**Catalysis:** Catalysts, Physical properties of catalyst, surface area, void volume, solid density, pore volume distribution, Classification and preparation of catalyst, catalyst promoters. Catalyst inhibitors, Catalyst poisons, Nature and Mechanism of Catalytic reactions.	**9**	**18**
6.	**Solid-Catalysed reactions: Kinetics:** Adsorption isotherms and rates of adsorption and desorption. Kinetic regimes, rate equations for surface kinetics, Pore diffusion, determining rate controlling step, experimental methods for finding rates, product distribution in multiple reactions.	**9**	**18**
7.	**Introduction to Catalytic Reactors:** Packed bed catalytic reactors, fluidized bed reactors, trickle beds, slurry reactors.	**6**	**9**

Suggested Specification table with Marks (Theory):

Distribution Of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
15	20	20	10	5	0

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Octave Levenspiel, "Chemical Reaction Engineering", 3rd Edition, John Wiley & Sons (Asia) pvt. Ltd.
2. H. Scott Fogler, "Elements of Chemical Reaction Engineering" 3rd Edition November, Prentice Hall of India Pvt Ltd
3. J.M.Smith, "Chemical Engineering Kinetics", 2nd edition, McGraw-Hill
4. L. D. Schmidt, the Engineering of Chemical Reactions, Oxford Press.
5. J. J. Carberry, "Chemical and Catalytic Reaction Engineering", McGraw Hill, New York, 1976.

Course Outcome:

At the end of this course student will be able to,

- Analyze the RTD studies for any flow reactor, to predict the deviation from ideal reactors by evaluating the dispersion number
- Analyze the various contacting pattern for two phase system and predict the rate equation for heterogeneous reactions.
- Analyze the best kinetic regimes for mass transfer and reaction for a given reaction and predict the rate equation.
- Predict the rate controlling step for the fluid - particle reactions.
- Classify catalysts and predict physical properties of catalyst, surface area, void volume, solid density pore volume distribution.
- Understand the nature and mechanism of catalytic reactions.

List of Experiments:

Experiments based on

- RTD studies in different reactors.
- Various models for non-ideal flow.
- Heterogeneous reaction kinetics etc.

Design based Problems (DP)/Open Ended Problem:

Open ended problems based on following topics can be selected,

- Study of various stimulus response techniques
- Study of resistance steps involved in heterogeneous reactions
- Finding rate expressions for given chemical reaction with mass transfer.
- And similar topics based on syllabus

Major Equipment:

- Tubular reactor for RTD analysis
- CSTR for RTD analysis
- Packed beds for RTD analysis etc

List of Open Source Software/learning website:

- NPTEL lecture series
- Literature available on Chemical Reaction Engineering
- MIT Open course lecture on Chemical Reaction Engineering

ACTIVE LEARNING ASSIGNMENTS:

Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.